

Diseño de estrategia de apertura para la interpretación gráfica-analítica a través de Desmos como preparación para el aprendizaje del cálculo diferencial

Design of opening strategy for graphic-analytical interpretation through Desmos as preparation for the learning of differential calculus

Desenho de estratégia de abertura para interpretação gráfico-analítica através do Desmos como preparação para a aprendizagem do cálculo diferencial

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Resumen

El dibujo fomenta la creatividad del alumno porque le permite documentar información y representar con claridad la comprensión de conceptos abstractos, de ahí que resulte muy útil el uso de la aplicación educativa Desmos, una herramienta didáctica que no solo se puede emplear en cualquier *smartphone*, sino que también permite un acercamiento ameno del estudiante hacia la geometría analítica. Por ese motivo, en el presente proyecto se ha usado el referido *software* para contribuir a la comprensión estudiantil del cálculo diferencial e integral. El objetivo final fue diseñar una estrategia de actividad de apertura/inicio para la secuencia didáctica desarrollada por Rojas Maldonado (2015), y de esa manera favorecer la creatividad y la comprensión gráfica-analítica de la matemática para el aprendizaje del cálculo diferencial y para preparar la construcción del concepto de límite. Este proyecto,

basado en el programa BYOD (*Bring Your Own Device*), se desarrolló en el lapso 2018-2019 cuando se explicaba la unidad temática *funciones* en la asignatura de Cálculo Diferencial. En el estudio participaron 123 alumnos tanto del bachillerato de Ingeniería y Arquitectura del Colegio Primitivo y Nacional de San Nicolás de Hidalgo como del segundo semestre de la licenciatura en Biotecnología, ambos grupos pertenecientes a la Universidad Michoacana de San Nicolás de Hidalgo. Los resultados demuestran que se pudo promover un desarrollo matemático y aplicar un modelo didáctico a figuras estructurales, las cuales se vincularon con situaciones cotidianas o fenómenos naturales que ayudaron a disminuir las dificultades entre el mundo matemático analítico y gráfico.

Palabras clave: Cálculo, Desmos, Gráfica, Interpretación.

Abstract

The drawing encourages the student's creativity because it allows to document information and clearly represent the understanding of abstract concepts, hence the use of the educational application Desmos, a didactic tool that can be used not only on any smartphone, but also that allows a pleasant approach of the student towards the analytical geometry. For this reason, in this project the aforementioned software has been used to contribute to the student's understanding of differential and integral calculus. The final objective was to design an opening / start activity strategy for the didactic sequence developed by Rojas Maldonado (2015), and in this way favor creativity and graphic-analytical understanding of mathematics for the learning of differential calculus and to prepare the construction of the concept of limit. This project, based on the BYOD program (Bring Your Own Device), was developed in the 2018-2019 period when the thematic unit functions in the subject of Differential Calculus was explained. The study involved 123 students from both the Bachelor of Engineering and Architecture of the Colegio Primitivo y Nacional de San Nicolás de Hidalgo and the second semester of the degree in Biotechnology, both groups belonging to the Universidad Michoacana de San Nicolás de Hidalgo. The results show that it was possible to promote a mathematical development and apply a didactic model to structural figures, which were

linked to everyday situations or natural phenomena that helped to reduce the difficulties between the analytical and graphic mathematical world.

Keywords: Calculus, Desmos, Graphics, Interpretation.

Resumo

Desenho promove a criatividade dos alunos, pois permite-lhe documentar informações e representam clara compreensão de conceitos abstratos, daí resultando o uso do aplicativo educacional Desmos, uma ferramenta educacional que não só pode ser usado em qualquer smartphone, muito útil, mas Isso também permite uma abordagem agradável do aluno em relação à geometria analítica. Por esta razão, o presente projeto tem usado o software referido contribuir para a compreensão do aluno de cálculo diferencial e integral. O objetivo final era projetar uma estratégia de atividade de abertura / start para a seqüência de ensino desenvolvido pela Rojas Maldonado (2015), e criatividade, assim, fomentar e compreensão graphic-analítico da aprendizagem da matemática do cálculo diferencial e preparar a construção do conceito de limite. Este projecto, com base na BYOD (traga seu próprio dispositivo) programa, desenvolvido no período 2018-2019, quando a unidade funciona temáticas no curso de cálculo diferencial explicou. O estudo envolveu 123 estudantes do ensino médio, tanto de engenharia e arquitetura Primitivo e Colegio Nacional de San Nicolas de Hidalgo na segunda metade do grau em Biotecnologia, ambos os grupos pertencentes à Universidad Michoacana de San Nicolás de Hidalgo. Os resultados mostram que poderia promover o desenvolvimento matemático e implementação de um modelo didático com dados estruturais, que foram relacionados com situações cotidianas ou fenômenos naturais que ajudou a reduzir as dificuldades entre o mundo da matemática analítica e gráfica.

Palavras-chave: Cálculo, Desmos, Gráfico, Interpretação.

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Introduction

In two investigations by Rojas Maldonado (2015, 2016) the didactic sequences for the teaching of the concept of limit were approached, which favored in a very small way their comprehension, as well as the involvement of mathematical software in the classroom by the students. Later, in another study, Rojas Maldonado (2017) identified the deficiencies in the evaluation of the learning of mathematics and showed the parameters that the Michoacán University of San Nicolás de Hidalgo has and applies as an institution in the degree in Biotechnology.

Then, in a following inquiry, Rojas Maldonado (2018) described a holistic and integrative evaluation of a continuous and qualitative nature that combined formal and informal procedures through the teaching of mathematization and mathematical modeling; In this last investigation, the aforementioned author tried to make the teacher use a creative and branched strategy so that the student conceived of mathematics as a science and understood physical phenomena through multidisciplinary.

The above is a sample of the various efforts made by teachers to incorporate technology in the classroom, which has led to the emergence of virtual teaching or e-learning (Knight, 2009), which can be defined as formal instruction that it is received at a distance thanks to the use of electronic devices such as computers or tablets. This type of teaching is characterized by the fact that the student can access information from remote places thanks to the use of the internet, which also happens with m-learning (Romrell, Kidder and Wood, 2014), which comes from examples and activities that establishes the SAMR model, that is, substitution, increase, modification and redefinition (Puentedura, 2012). This type of teaching is based on mobile learning, which is materialized through the use of different applications and social networks.

Likewise, we can mention b-learning (Martí, 2009), a methodology that combines pedagogical and didactic theories to develop educational activities in both physical and virtual environments. This teaching method links elements of m-learning and e-learning in order to enhance the strategies implemented and impact more decisively on the intellectual development of the student.

In addition to the above, we can mention the emergence of the didactic strategy called gamification, which is considered as "a tool to encourage behavioral change and promote desired attitudes in many fields" (Almarshedi, Wanick, Wills and Ranchhod, 2017) . One of the variables on which this strategy is based is drawing, which, as mentioned by Gómez Llombart and Gavidia Catalán (2015), offers great advantages in the learning process:

The drawing strategy improves the results in observational processes with respect to the task of describing, especially in the acquisition of information and its communication (...). [In this sense, there is] the need to include the drawings and descriptions in the formation of the professed, so that they can be used later in the modeling of processes and concepts by their students. It is an appropriate activity for the search of the "universals" that Plato points out, or of the "essence" of Aristotle, as the "common idea" of all the ants, the mental model that makes up "the" ant, which belongs to the group of the arthropods with characteristics that define it (p. 453).

Now, in this context of technological innovations implemented in education, we can mention the application Desmos, a didactic tool that has served to replace the graphing machines. This has the particularity that it can be executed from different operating systems, which has generated a revolution in the way of teaching mathematics, since it offers a different approach to the solutions of numerical and symbolic problems, which helps not only to create environments of collaboration (Holubz, 2008), but also to focus in a didactic way more advanced mathematical concepts (Jones, 2010).

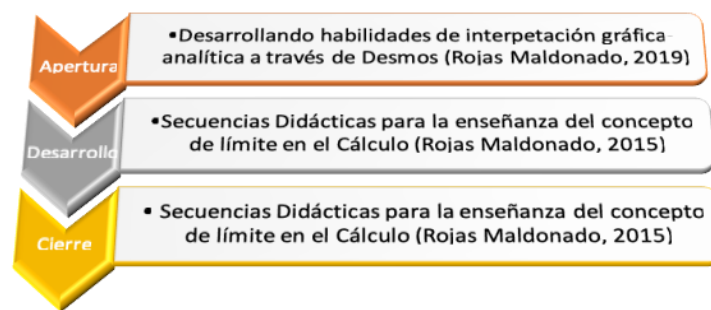
Objective

The objective of this research is focused on designing an opening / starting activity strategy for the didactic sequence developed by Rojas Maldonado (2015), and in this way favor creativity and graphic-analytical understanding of mathematics for learning the calculation differential and to prepare the construction of the limit concept.

Methodology

The present study has been based on the qualitative-interpretative paradigm, with a constructivist approach, since it has been based on the principles of flexibility, adaptability, synergy, holistic, interdisciplinarity, relativity, continuity, systematicity, reflexivity, receptivity and ethics. This research, moreover, is part of a general project that can be illustrated in Figure 1:

Figura 1. Diagrama de flujo de la ubicación del proyecto



Fuente. Elaboración propia

The information presented in this paper is located in the opening phase, as shown in Figure 2:

Figura 2. Componentes del proyecto



Fuente: Elaboración propia

This project was developed in the 2018-2019 period when the thematic unit of functions in the subject of Differential Calculus was explained. The study involved 123 students from both the Bachelor of Engineering and Architecture of the Primitive and National College of San Nicolás de Hidalgo and the second semester of the degree in Biotechnology, both groups belonging to the Michoacana University of San Nicolás de Hidalgo.

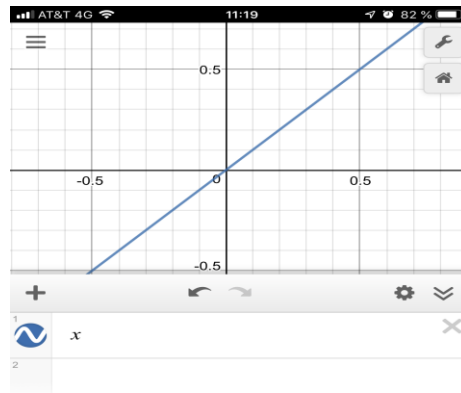
The project was based on the BYOD program (Bring Your Own Device), used on a daily basis, although this time it focused on comprehension and computation tasks to explore diverse edges of multiple mathematical problems. For this, the participants were asked to install the free Desmos application on their mobile devices.

Developing

Phase 1. Familiarization of the participants with the Desmos application

In this phase we tried to familiarize the participants with the Desmos application. Likewise, conditions, themes and concepts different from those used in the Rojas Maldonado project (2015) were used in order to promote multidisciplinary and implement it in later semesters, specifically in the subject Differential Equations and Thermodynamics.

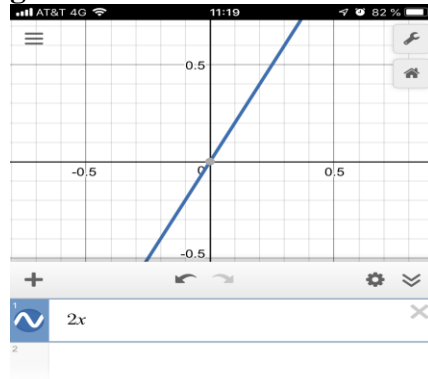
Figura 3. Gráfica de la función “espejo” en la aplicación Desmos (función $f(x) = x$)



impulsado por
desmos

Fuente: Elaboración propia

Figura 4. Gráfica de la función doble

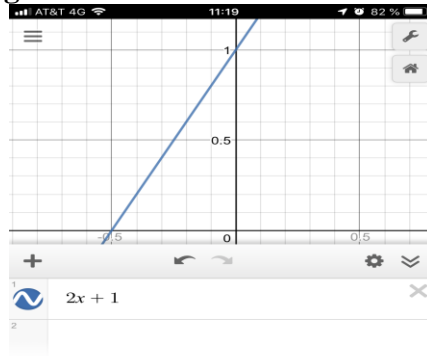


Fuente: Elaboración propia

Later, they were asked about the difference between both graphs, for which it was explained that these are first-degree equations that intersect at the origin of the Cartesian coordinates. Likewise, previous definitions of slope and ordered to origin were resumed.

Then they were plated two questions: what should they do to make the graph cut on the axis of the ordinates with a value of 1? and what function would define that? In this way they deduced the steps that had to be followed and the way in which the function was transformed by adding, subtracting, multiplying and dividing by a constant.

Figura 5. Gráfica de la función $2x + 1$

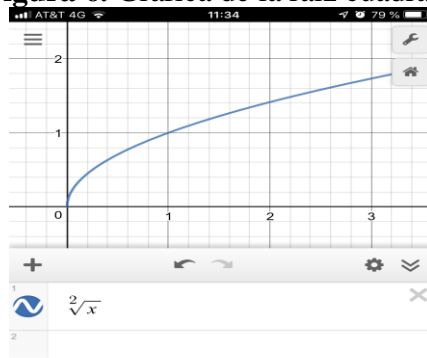


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Fuente: Elaboración propia

Likewise, they were invited to graph other functions to stimulate their curiosity and explained that the functions were like the fingerprints of mathematics, that is, they are not the same, although some are similar.

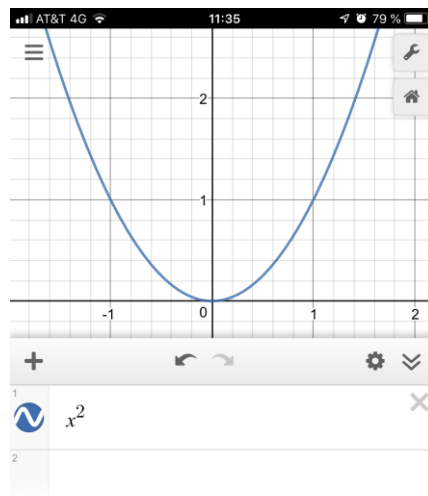
Figura 6. Gráfica de la raíz cuadrada



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Fuente: Elaboración propia

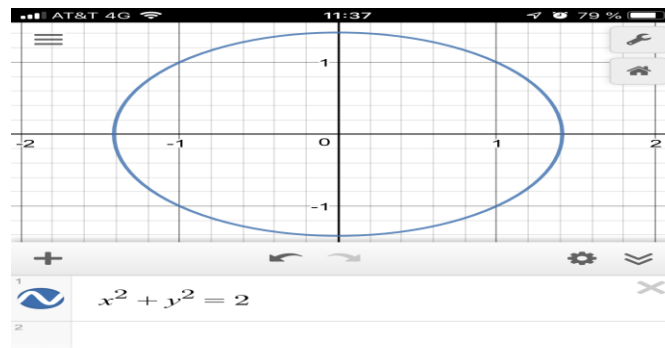
Figura 7. Gráfica de una ecuación cuadrática con foco en el origen



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Fuente: Elaboración propia

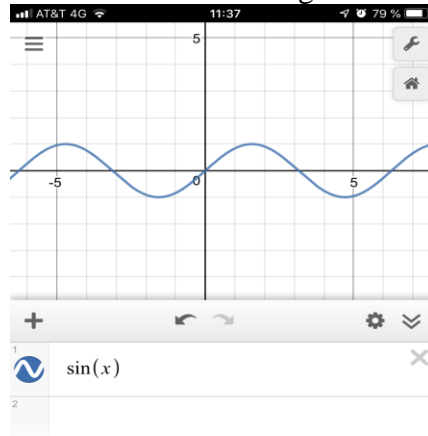
Figura 8. Gráfica de una circunferencia con centro en el origen y radio raíz de 2



impulsado por
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Fuente: Elaboración propia

Figura 9. Gráfica de la función trigonométrica seno de x



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Fuente: Elaboración propia

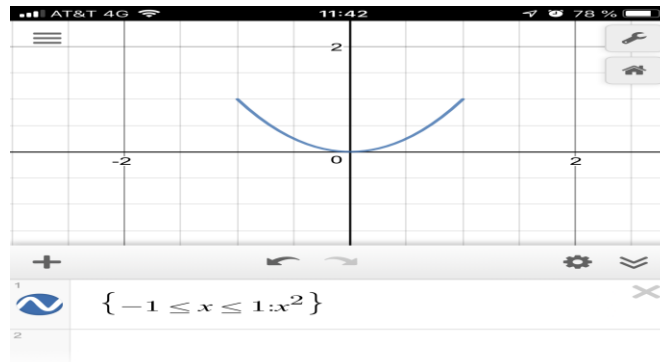
The teacher, on the other hand, explained in an introductory way how to graph a line and a circle through the equation in the application and how to make the relevant transfers of the graphs, either in the X axis or the Cartesian plane. The way to introduce logarithmic and exponential trigonometric functions was also taught, as an approach to the graphing of functions in differential calculus.

In this regard, it is worth emphasizing that these processes must be explained before the concepts of domain and image of a function, because the intention is for the student to discover and internalize these conceptual needs and locate the "problem points" (points that are not in the domain of a function).

Phase 2. Delimitation of a function

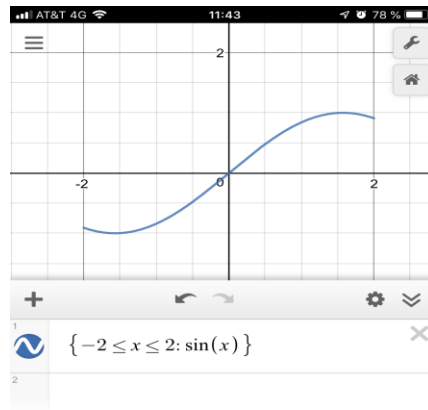
When the students were able to graph a variety of functions and move them in all directions, the definition of function by pieces was presented, for which the knowledge of the inequalities (thematic unit 1 of the Differential Calculus course) was taken into account to use them in the Desmos application.

Figura 10. Gráfica de una ecuación cuadrática con foco en el origen y delimitada en el intervalo $[-1,1]$



Fuente: Elaboración propia

Figura 11. Gráfica de la función seno de x delimitada en el intervalo $[-2,2]$



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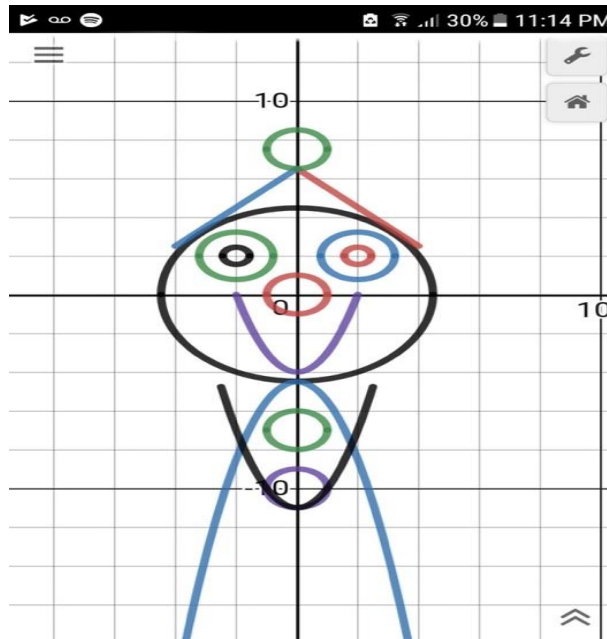
Fuente: Elaboración propia

Results

Phase 3. Incorporation of functions by pieces

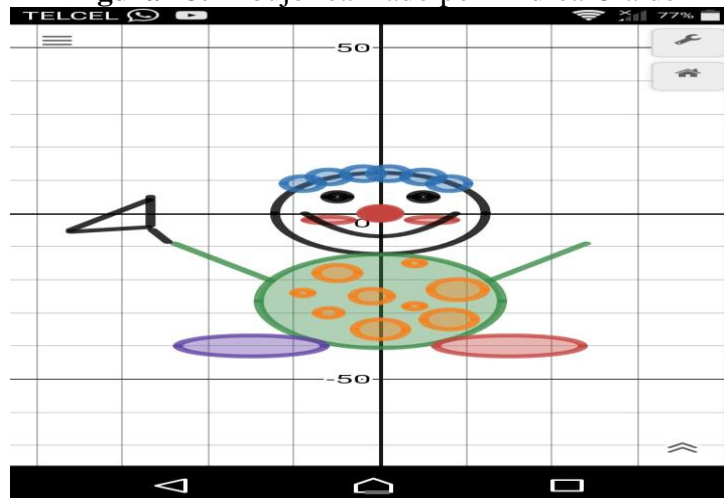
In this phase the participants were asked to draw characters that involve analytical geometry, delimiting the functions through intervals for their correct projection in the drawing. For this, it was asked to graph a clown using functions by pieces.

Figura 12. Dibujo realizado por Daniela Rosales



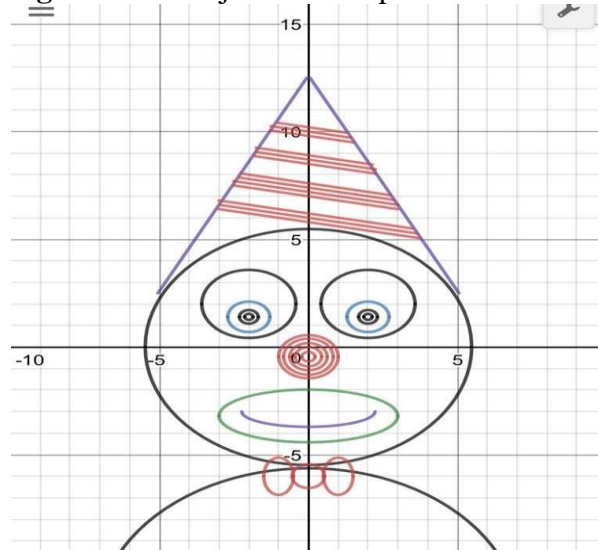
Fuente: Elaboración propia

Figura 13. Dibujo realizado por Andrea Olalde



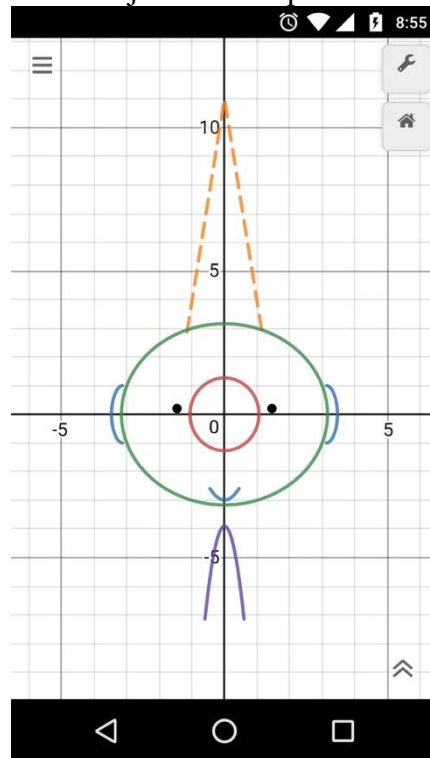
Fuente: Elaboración propia

Figura 14. Dibujo realizado por Paola Moreno



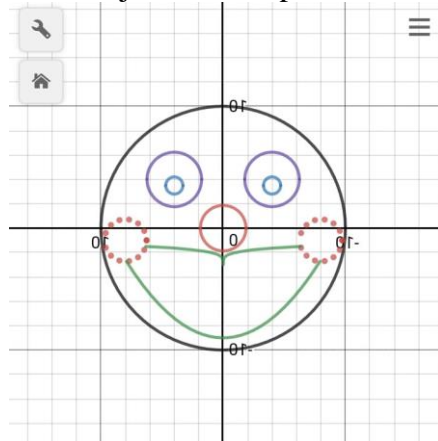
Fuente: Elaboración propia

Figura 15. Dibujo realizado por Camilo Aboyte



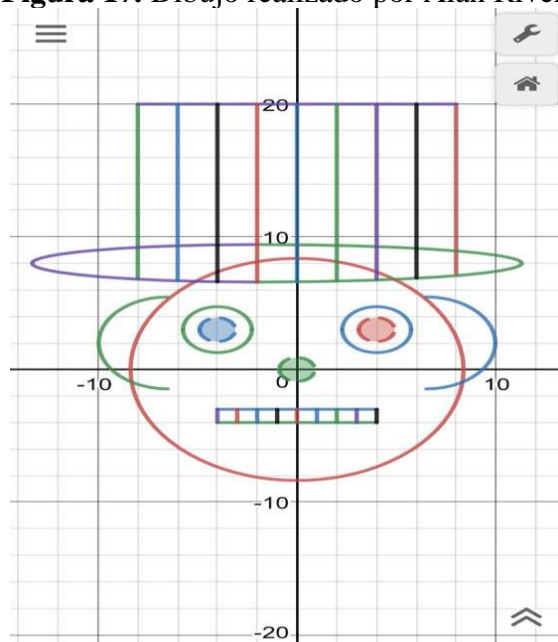
Fuente: Elaboración propia

Figura 16. Dibujo realizado por Antonio Magaña



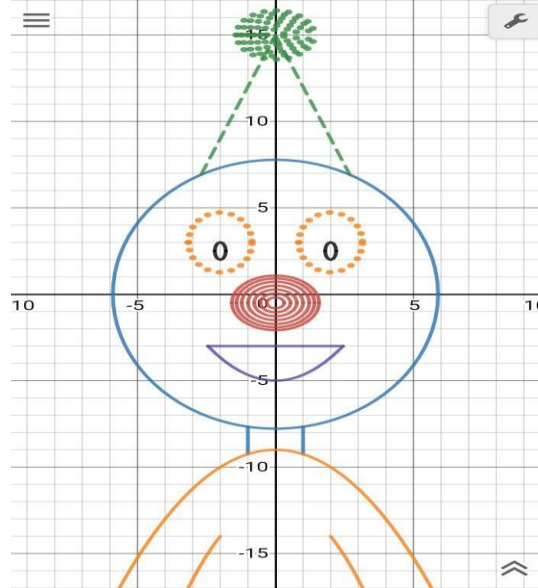
Fuente: Elaboración propia

Figura 17. Dibujo realizado por Alan Rivera



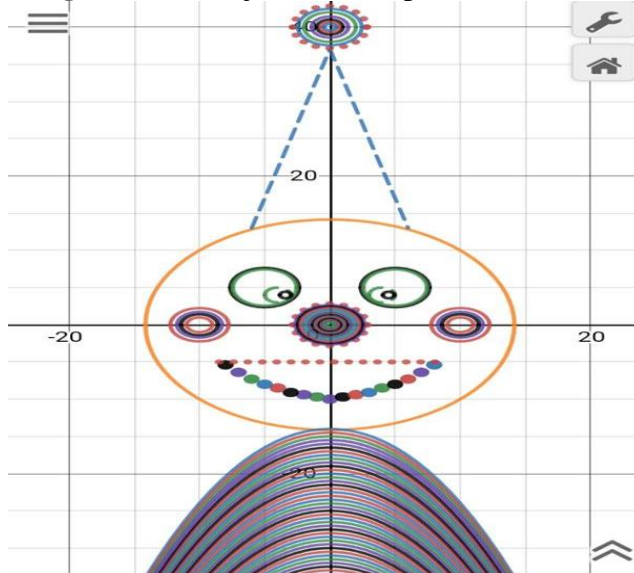
Fuente: Elaboración propia

Figura 18. Dibujo realizado por Itzel Montoya



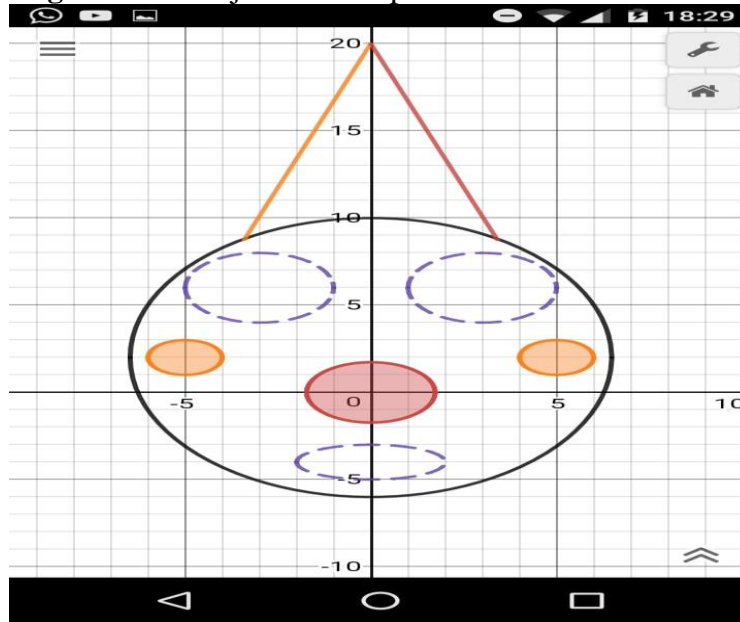
Fuente: Elaboración propia

Figura 19. Dibujo realizado por Paola Guizar



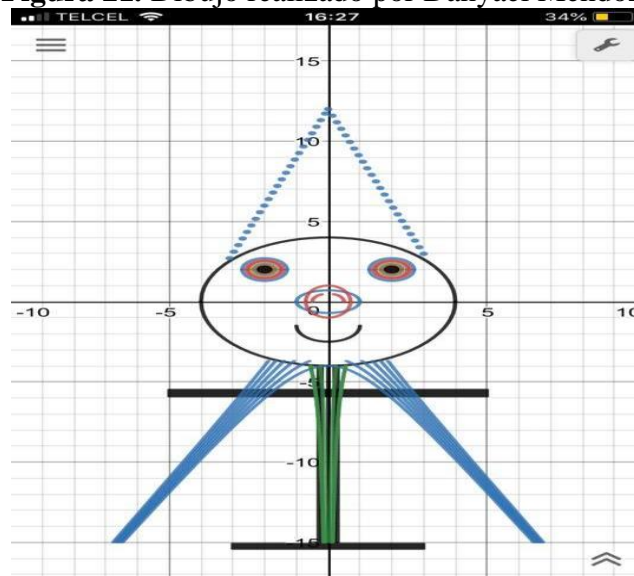
Fuente: Elaboración propia

Figura 20. Dibujo realizado por Sandra Paulina Blancas



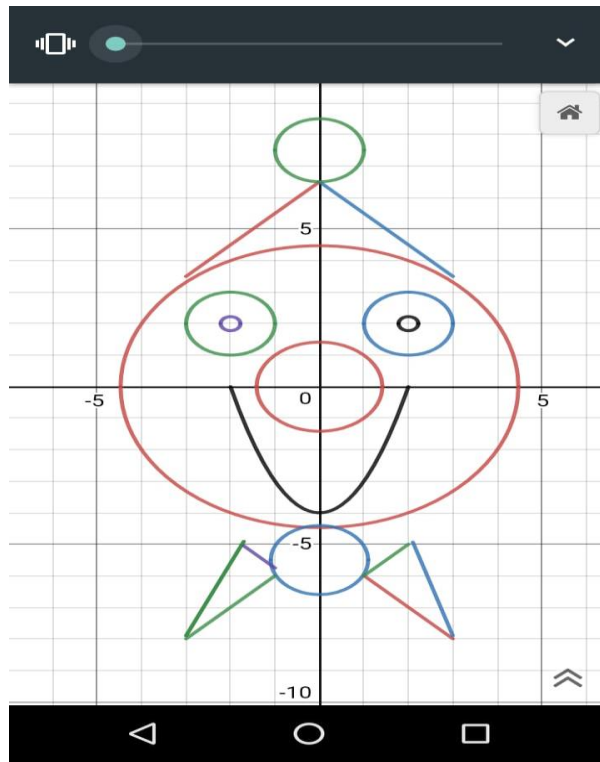
Fuente: Elaboración propia

Figura 21. Dibujo realizado por Danyael Mendoza



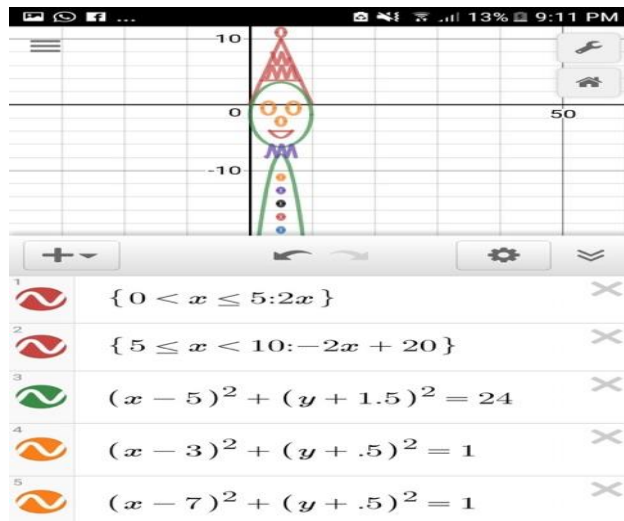
Fuente: Elaboración propia

Figura 22. Dibujo realizado por Axel Daniel Sánchez



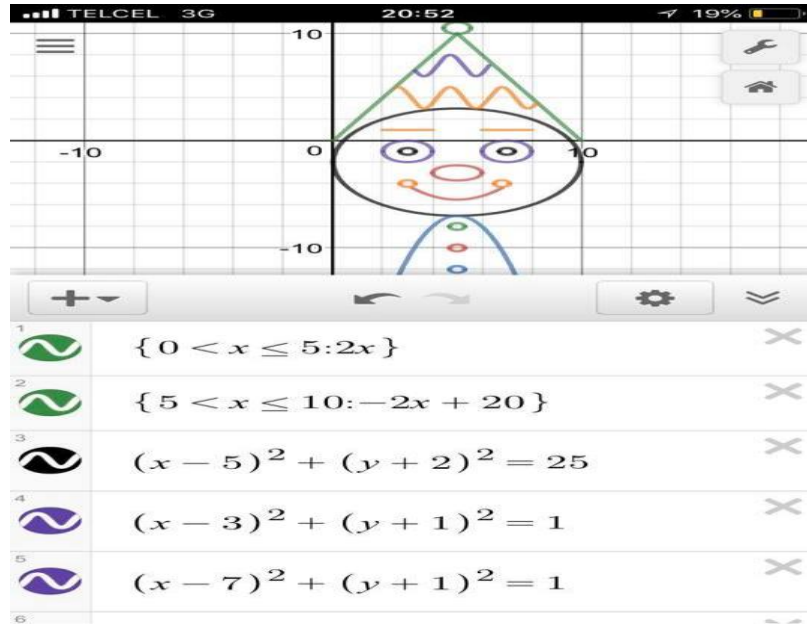
Fuente: Elaboración propia

Figura 23. Dibujo realizado por Andrea Pelagio (alumna de Biotecnología)



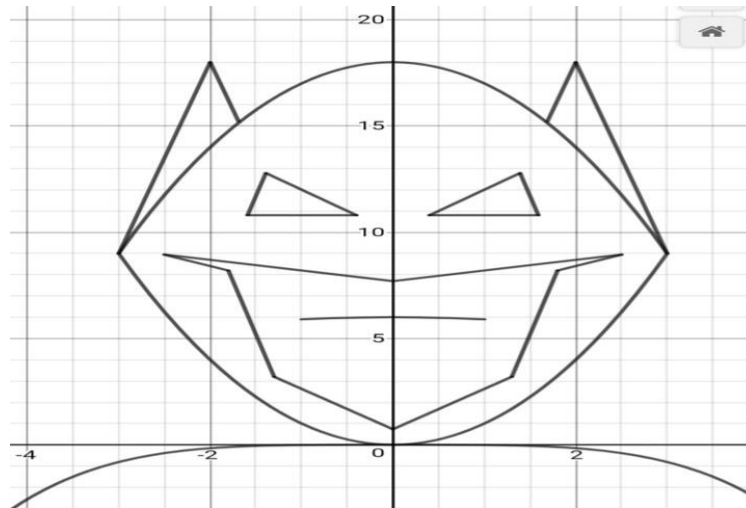
Fuente: Elaboración propia

Figura 24. Dibujo realizado por Jaqueline Flores (alumna de Biotecnología)



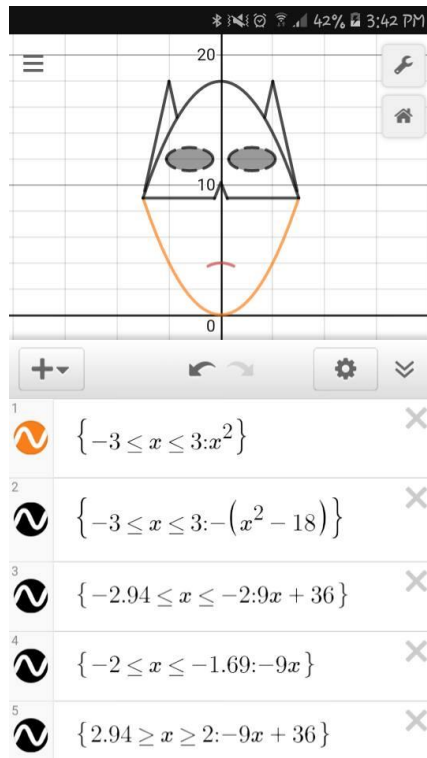
Fuente: Elaboración propia

Figura 25. Dibujo realizado por Edgar Tello (alumno de Biotecnología)



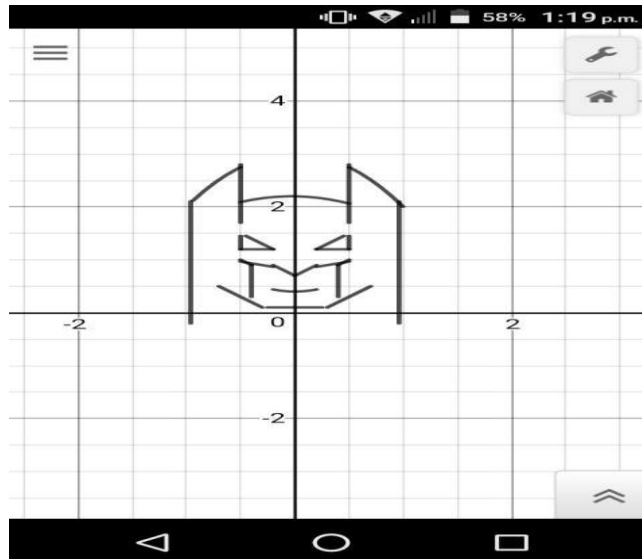
Fuente: Elaboración propia

Figura 26. Dibujo realizado por Katia López (alumna de Biotecnología)



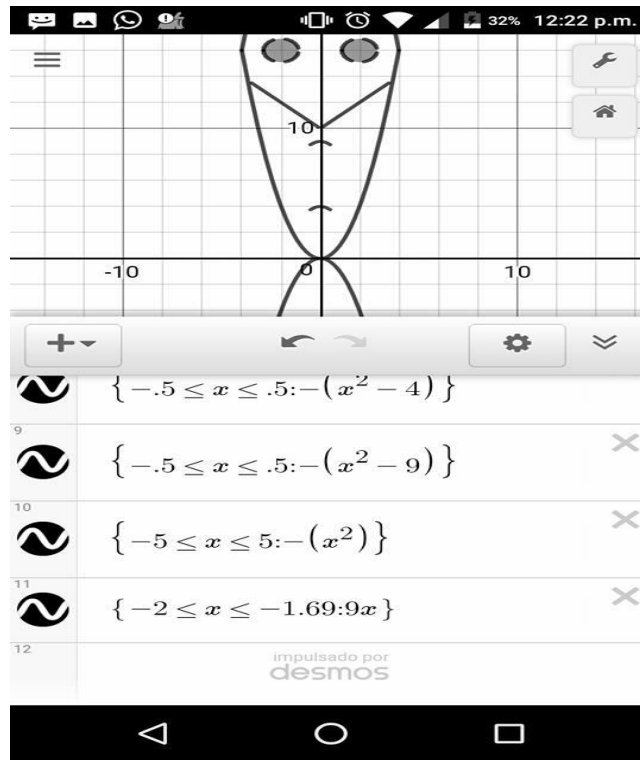
Fuente: Elaboración propia

Figura 27. Dibujo realizado por Samantha Montelongo (alumna de Biotecnología)



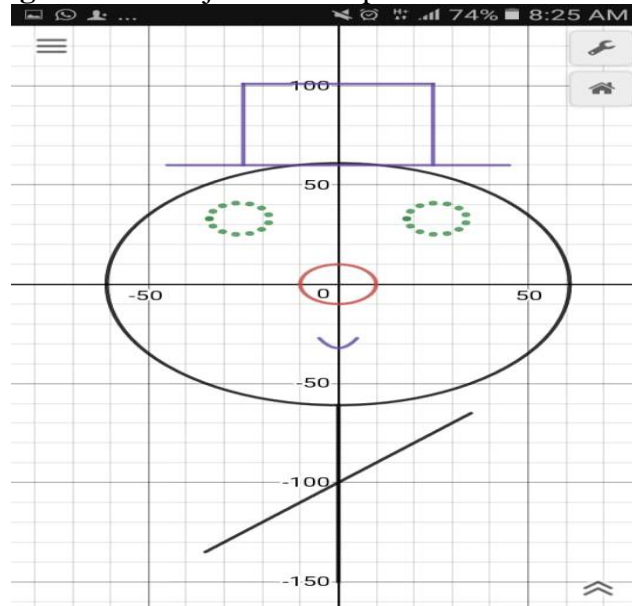
Fuente: Elaboración propia

Figura 28. Dibujo realizado por Saira Estrada (alumna de Biotecnología)



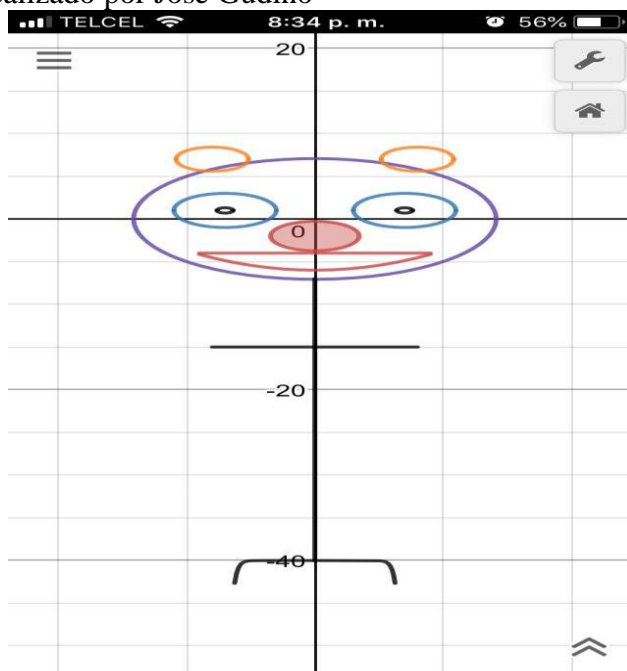
Fuente: Elaboración propia

Figura 29. Dibujo realizado por Valentina Reséndiz



Fuente: Elaboración propia

Figura 30. Dibujo realizado por José Gudiño



Fuente: Elaboración propia

Conclusions

The activities described in the previous section allowed the students to understand differently the definitions of domain and image of a function, which is essential for the development of content limits of a function, as was explained by the same author in Sequences didactic for the teaching of the concept of limit in the calculation. In addition, they served to evaluate mathematics in a more palpable and transparent way and to identify, through drawing and creating a cognitive analogy, comprehensive difficulties of mathematics.

Likewise, it was possible to promote a mathematical development and apply a didactic model to structural figures, which were linked to everyday situations or natural phenomena that helped to reduce the difficulties between the analytical and graphic mathematical world. In other words, the constructivist conceptions of mathematics had a strong implication in the students, since they could make sense and verify what they were

doing. In this way, an analogy was established with the everyday world to solve an infinity of problems through sketches and cognitive tools to represent ideas.

On the other hand, when applying the project, learning was promoted from a social perspective, since with the interaction within the group, collaborative ideas were generated to improve each drawing. In this regard, it is worth emphasizing that the importance of the Desmos application was not only that it contributed to the training of the students, but also stimulated their motivation and interpretative abilities of the equations proposed.

With this strategy, finally, the teacher went from being an expository figure of knowledge to a feedback of learning, which was achieved by clarifying the specific doubts that were arising. The realization of drawings, in short, allowed to create emotional bonds between the classmates while they were building their mathematical knowledge.

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